WIMP SEARCHES WITH THE AMANDA DETECTOR: RESULTS AND PERSPECTIVES

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(for the AMANDA collaboration)

- The AMANDA detector
- Signal simulation
- Results from AMANDA-B10 (1997 data)
- Something about AMANDA-II (2000 data)
- The (not so far) future: IceCube

The AMANDA collaboration (in short):

The detector:

AMANDA-B10 (1997):

cylinder of 500m. H x 120m. D

10 strings

302 Oms

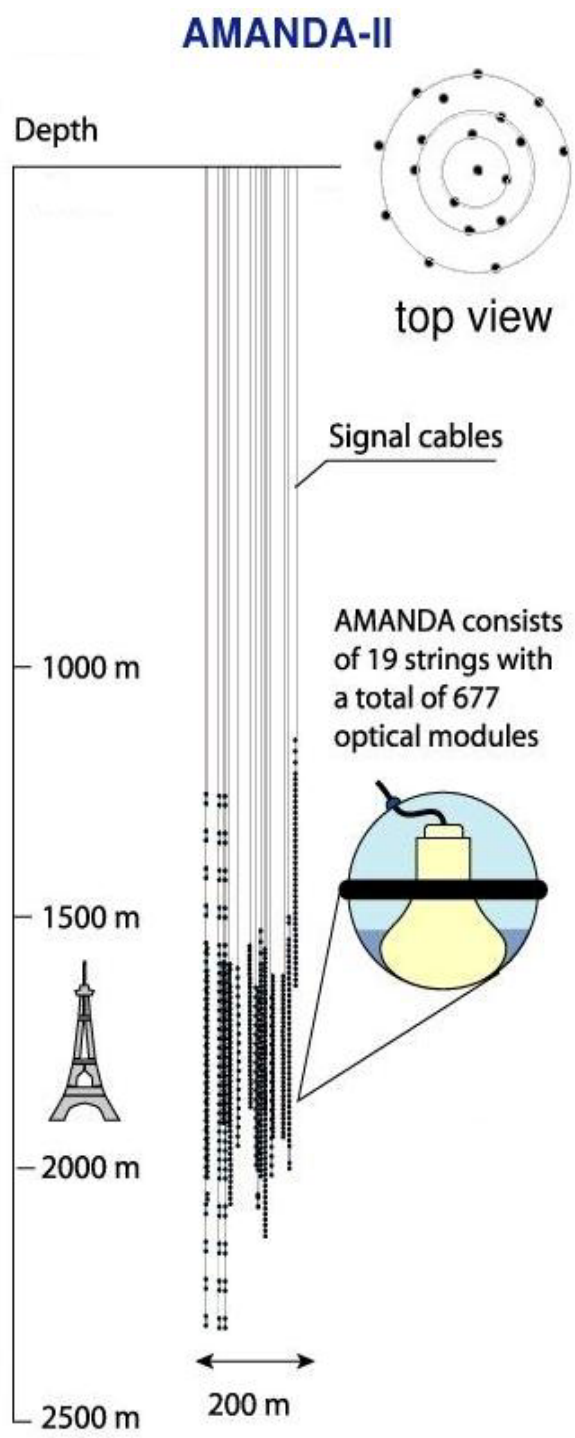
AMANDA-II (2000):

cylinder of 500m. H x 200m. D

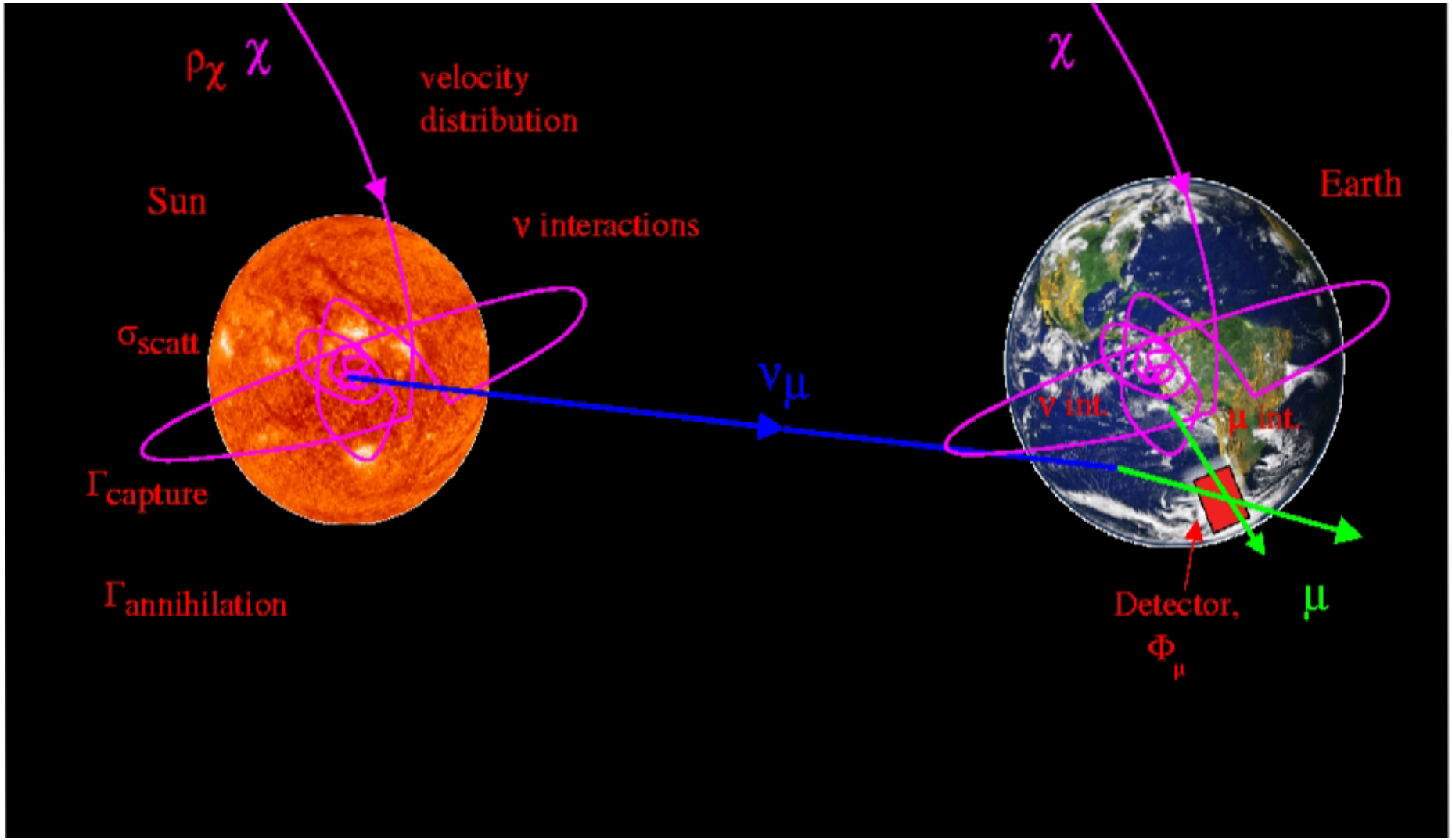
19 strings

(3 of them instrumented over 1-km. for ice studies)

677 OMs



WIMP (χ) CAPTURE



SIGNAL SIMULATION I: PARTICLE PHYSICS INGREDIENTS

One sets limits to what one simulates!

MSSM with 7 parameters

- Higgsino mass parameter m [-50000,50000] GeV
- Gaugino mass parameter M_2 [-50000,50000] GeV
- Ratio of Higgs VEV, tanb [1,60]
- mass of CP-odd Higgs, m_A [0,10000] GeV
- Scalar mass parameter m_0 [100,30000] GeV
- SUSY breaking parameters, A_b and A_t [-3,3] on A_i/m_0

No restrictions from supergravity

- except for gaugino mass unification at GUT scale

Parameter space scanned and models already rejected by accelerator searches discarded

SIGNAL SIMULATION II: COSMOLOGY and YET MORE PARTICLE PHYSICS INGREDIENTS

For each model, the neutralino relic density, $\Omega_\chi h^2$, is calculated and only models with $\mathbf{0.025 < \Omega_\chi h^2 < 1}$ are kept

A galactic DM density of **0.3 GeV/cm^3** and a DM velocity dispersion of **270 km/s** have been assumed

Annihilations into $\chi\chi$ 1 cc, bb, tt, $\tau\tau$, WW, ZZ were considered for 6 neutralino masses: 100GeV, 250GeV, 500GeV, 1000GeV, 3000GeV and 5000 GeV

Hadronization and decay of the resulting products simulated with PYTHIA

The resulting muon is tracked including energy losses until it decays or passes the detector

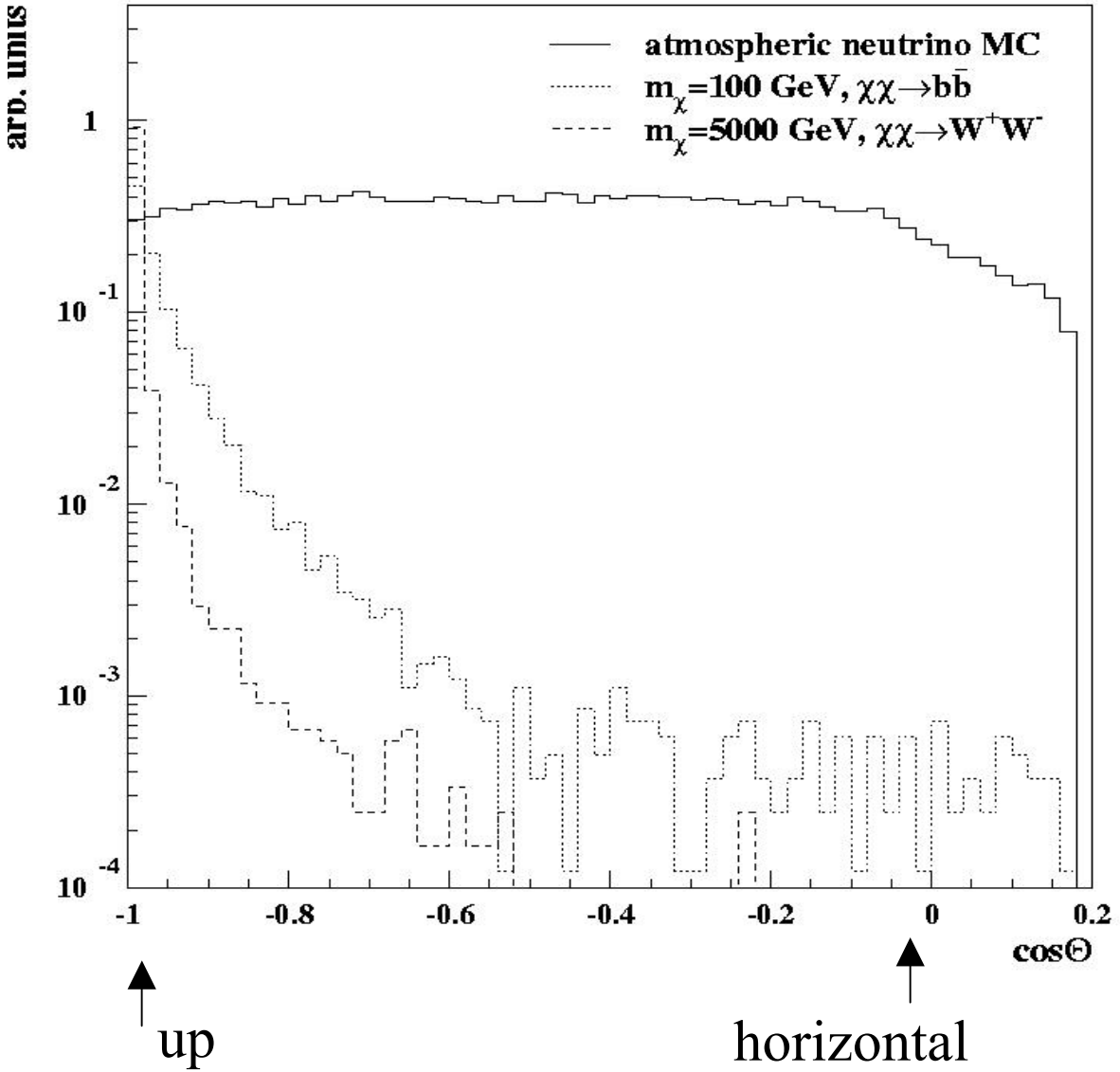
WIMPS FROM THE EARTH IN AMANDA-B10: RESULTS

Backgroud to this search:

atmospheric neutrinos

Main handle:

angular distribution

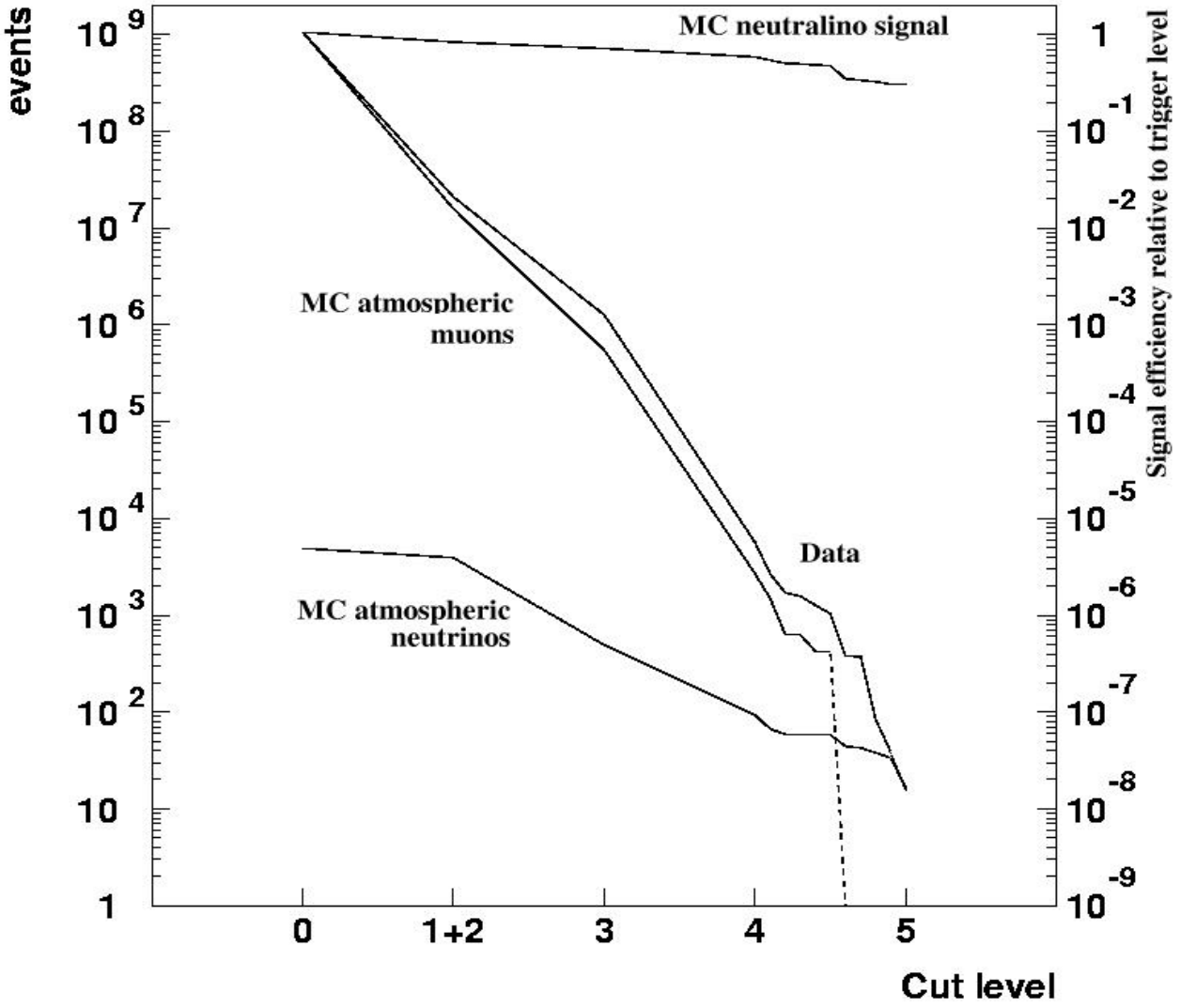


Analysis strategy:

- Unstable runs, X-talk and noise hit cleaning
- Fast (line) fit and loose zenith angle cut (>70^{o})
- Likelihood reconstruction with use of photon scattering probabilities in ice
- Further cuts based on:
  - Sphericity of hit distributions
  - Track length
  - Number of hits due to unscattered photons
  - Number of hit channels
  - Summed hit probability of the hit modules
  - z-component of the center of gravity of hits
  - Event time flow
- Mass-dependent final angular cuts as to contain 90% of a possible WIMP signal

Challenge

Achieve a rejection factor of ~10^8 due to the presence of a strong atmospheric muon background



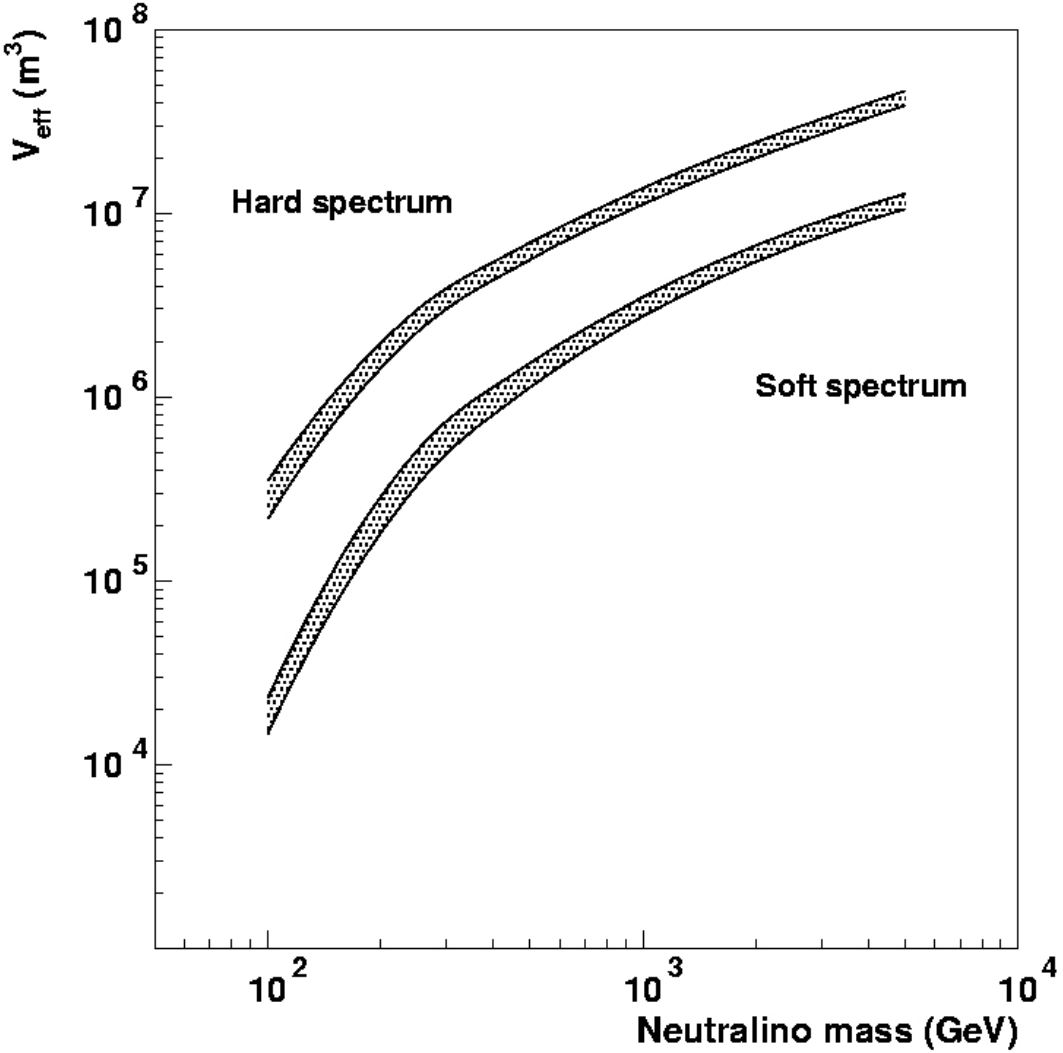
Sensitivity to signal given by

$$V_{eff}=N_{finalcut}/N_{gen} \times V_{gen}$$

Observable quantity

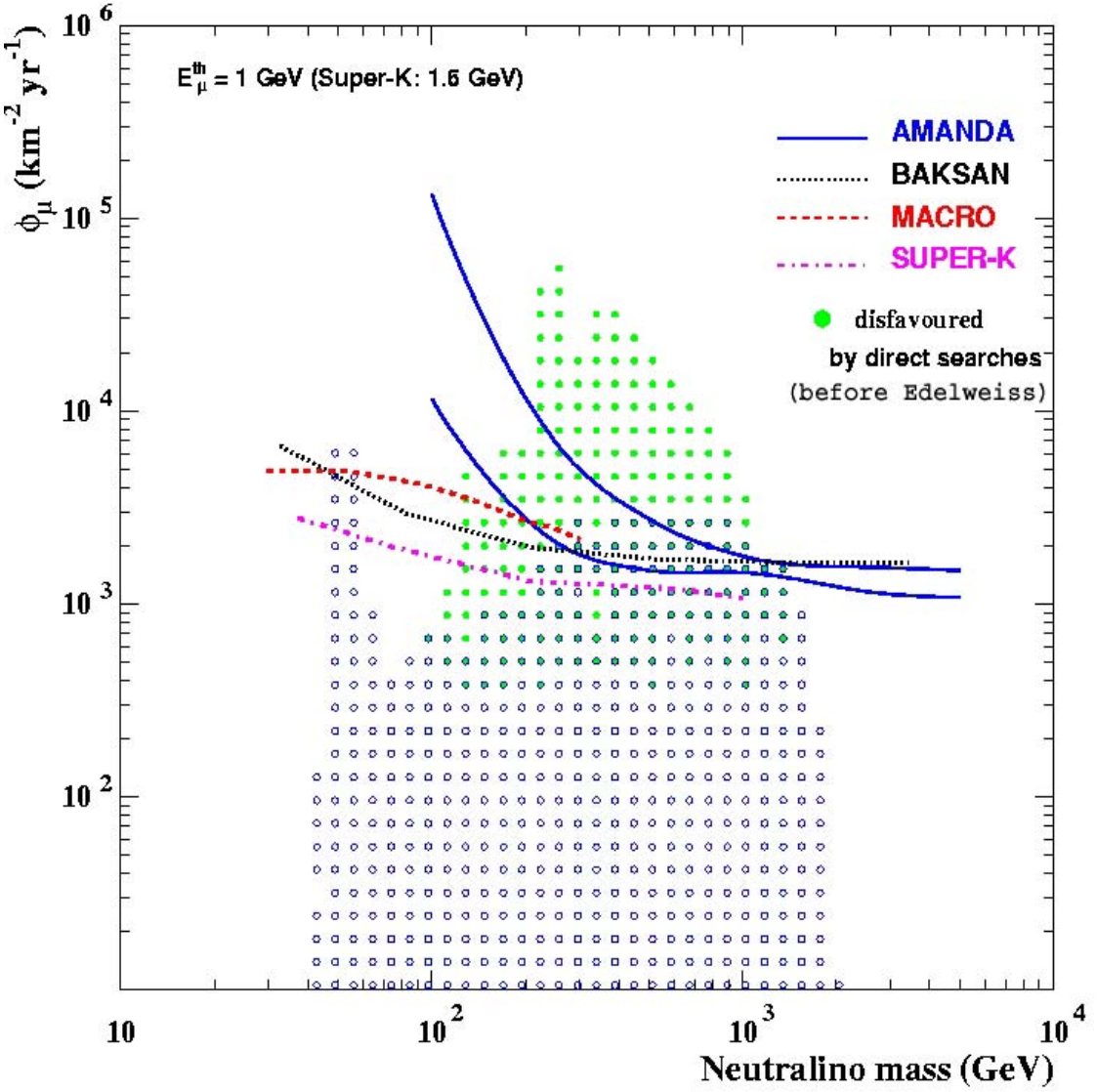
$$\Gamma_{\nu\mu} = N_{90}/V_{eff}\, t$$

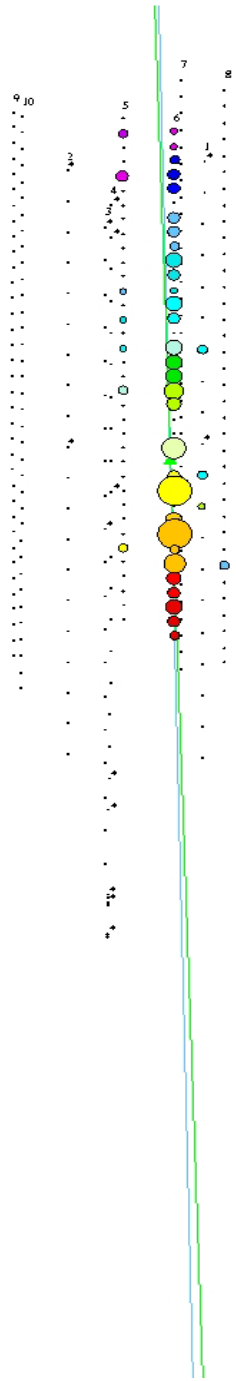
From $\Gamma_{\nu\mu}$ to Φ_{μ} at any threshold and angular region

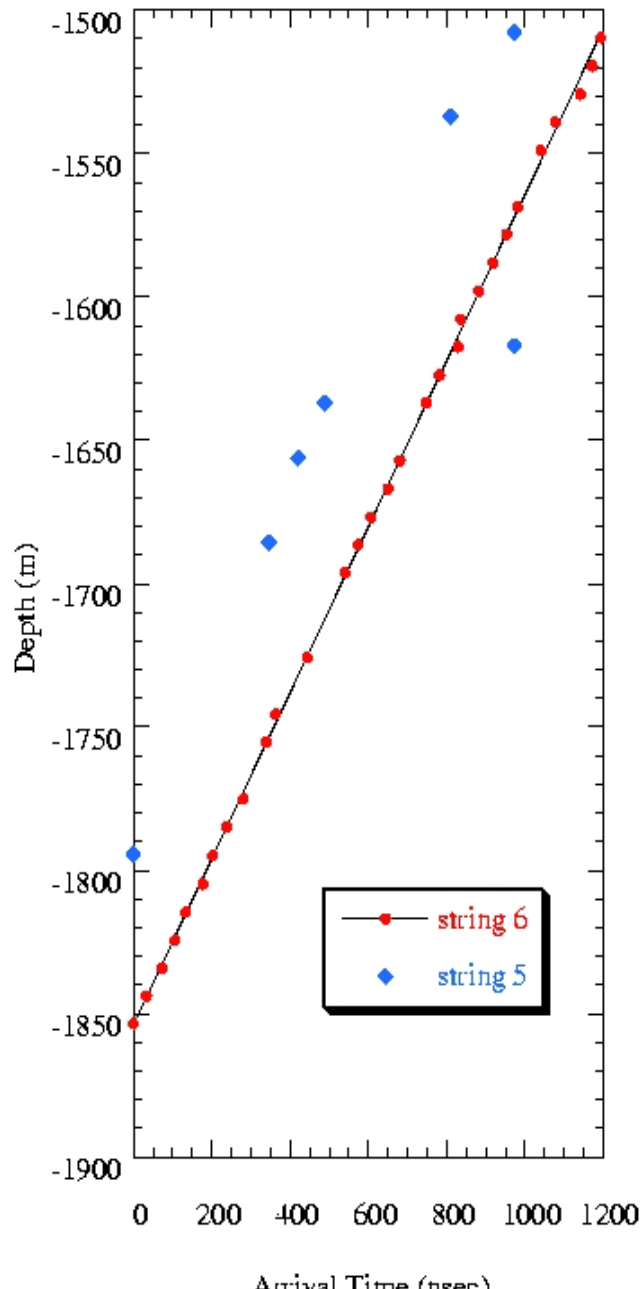


AMANDA-B10 limit on the muon flux from the center of the Earth compared with current indirect limits (Phys. Rev. D66, 032006)

AMANDA curves include the effects of systematic uncertainties in N_{90}






-1500
-1550
-1600
-1650
-1700
-1750
-1800
-1850
-1900
Depth (m)
0
200
400
600
800
1000
1200
string 6
string 5

WIMPS FROM THE EARTH: AMANDA-II

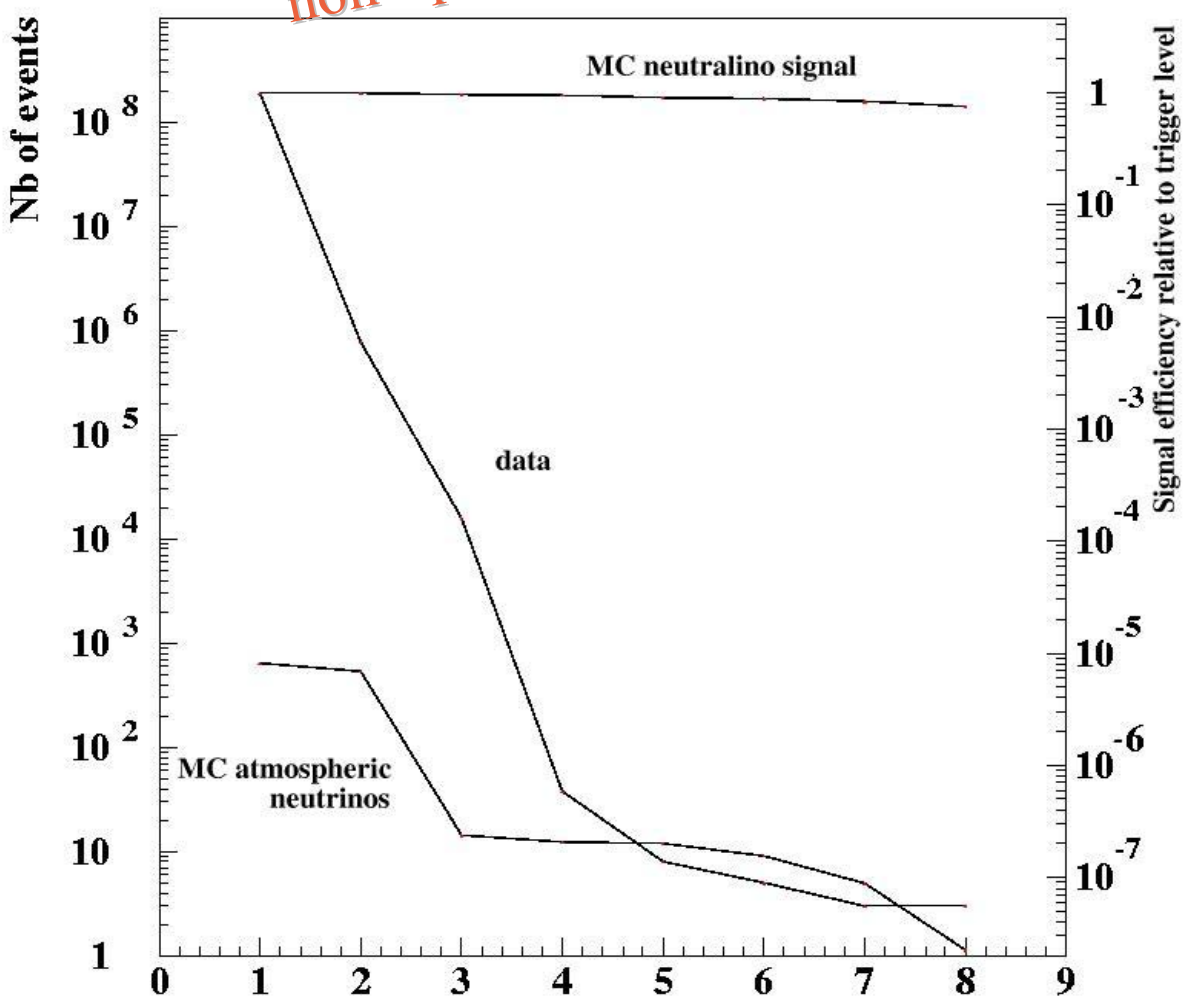
Running since 2000

- 1.3 x 10^9 events collected in 2000
- 1.5 x 10^9 events collected in 2001
- ~1.4 x 10^9 events collected to date 2002

Bigger detector:

- x 2 in V_{eff} for WIMP signal from the Earth
- Simpler cuts achieve necessary rejection:
- NN + 1 track quality cut

Preliminary! 20% of 2000 data. non-optimized cuts!



Bigger detector...

Higher sensitivity to horizontal tracks. Makes it suitable for searches for WIMP signals from the Sun (Sun at most at 22.5^{o} below horizon at the Pole)

Main challenge: rejection of down-going misreconstructed atmospheric muons

Handle: Sun is a point source: background estimated from data with on-source/off-source method

Analysis of 2000-01 data for WIMP signal from the Sun under way

2002 data being filtered on line at the Pole

WIMPS FROM THE SUN: ICECUBE

ICECUBE:

Really big!

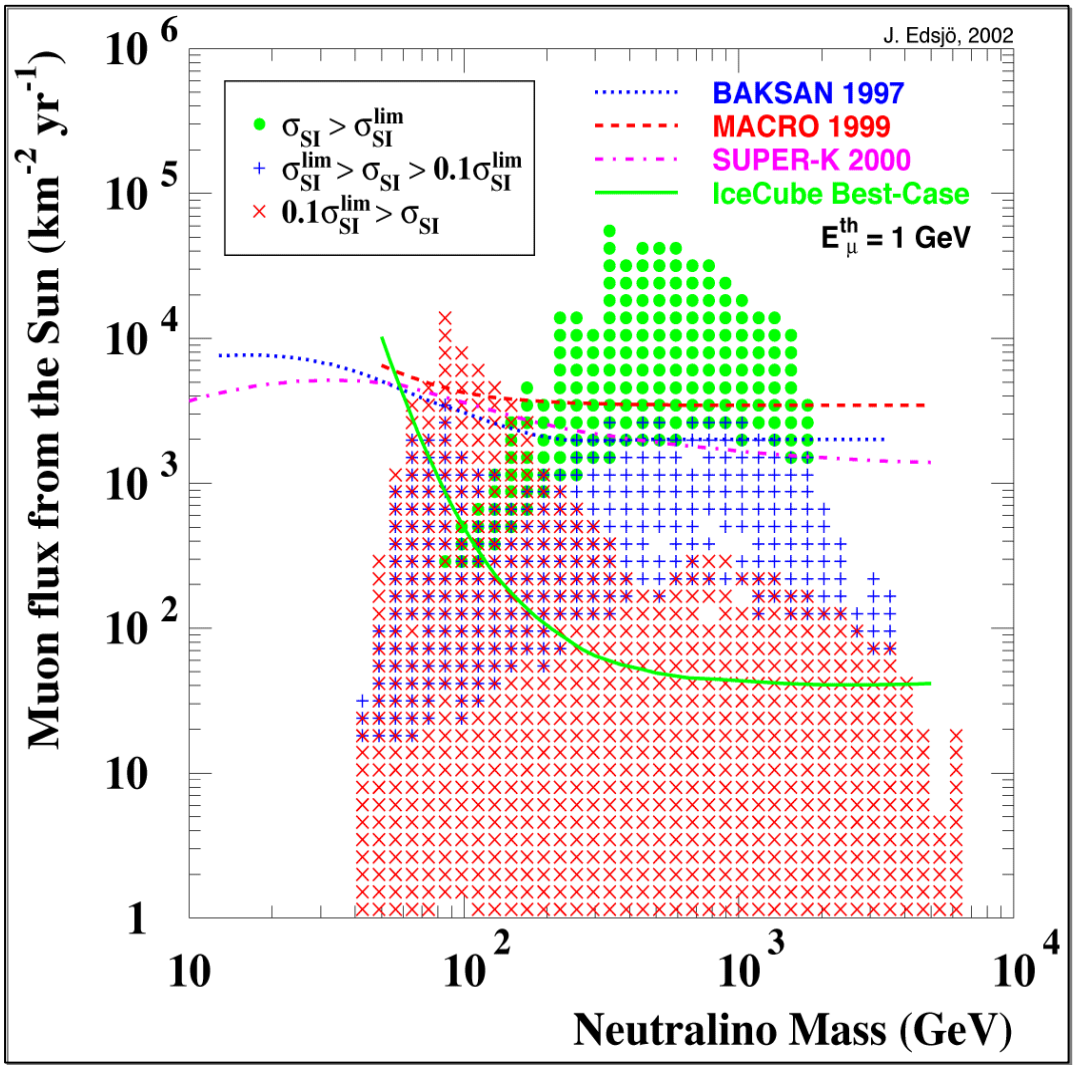
80 strings/5000 OMs

1 Km^3 instrumented volume between 1450-2450 m depth

Excellent horizontal HE sensitivity (1 Km lever arm)

Competitive with direct searches for some combinations of SUSY parameter space

expected sensitivity of IceCube to WIMP-induced muon flux from the Sun



CONCLUSIONS

Large neutrino telescopes can be succesfully used for indirect DM searches

Results from searches for a WIMP signal from the Earth with AMANDA-B10 published

Recent results from direct searches make the search using the Sun as source the most promising path for DM searches with neutrino telescopes

AMANDA-II/IceCube will explore the possible signal from the Sun